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ANALYSIS OF METALLIC RESIDUES IN GOAT TISSUES THROUGH ICP-OES

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ABSTRACT

A study was undertaken to analyze the metallic residues viz., cadmium, chromium, copper, lead, nickel and zinc in goat tissues (muscle, liver and kidney) collected from industrial and non-industrial areas of Coimbatore district at two distinct seasons. A sum of 240 samples were collected and subjected to acid digestion (wet ashing) and then analyzed by using inductively coupled plasma-optical emission spectrometry (ICP-OES). Result reveals that, among the three tissues examined liver had higher concentration of cadmium, chromium, copper lead and nickel, with the exception of zinc in the muscle. Tissues collected from industrial area had recorded higher concentration of metallic residues than from the non-industrial area, with the exception of nickel. Samples collected during summer season had higher level of metallic residues than rainy season. From the study it was concluded that, all the analyzed metallic residues were well within prescribed limit proposed by FSSA, 2011.

KEYWORDS: Cadmium, Chromium, Copper, Lead, Nickel, Zinc

INTRODUCTION

India is endowed with rich livestock resources of 529.69 million, out of which goat alone contributes140.54 million and this population is progressively growing at the rate of 3.10% annually (AHS, 2010). As per FAO 2012 report, the present meat production of India is estimated to be around 6.27 million tons, which is nearly 2.21% of the world's meat production. Extensive system of goat rearing is the most commonly prevailing practice of animal production in India. Hence, the meat obtained from such animals is considered to be lean and it also contains several health promoting antioxidants like carnitine and aniserine. Moreover, there is a great demand for goat meat in the domestic market as well as in other countries.

Industrialization and urbanization are the two prime factors paved a way for environmental pollution. As per central pollution control board report, Tamil Nadu stands second place in the industrialization next to Maharashtra, but state owned pollution control board has regularly monitored and declared few places as industrially polluted area based on the level of pollutant prevailing in these places. Among the different chemical pollutant, heavy metals is considered as one of the most important threats to human and animal’s health as these metals cannot be degraded and stay permanently in the environment leading to bioaccumulation. Animals raised in such polluted areas or fed with feed and fodder grown from such areas, there is an ample opportunities to acquire and harbor higher level of these heavy metals in their produce viz., meat, milk and egg due to bioaccumulation and biomagnifications. Heavy metals gain entry into human body and results in

accumulation in vital organs causing disorders such as necrosis of liver, damage of nephrons in kidney, hematological aberration and decline in growth rate (Mahimairaja and Shenbagavalli, 2007). It also gains greater significance owing to legal, commercial, bilateral relationship between the countries involved in export and import of meat and meat products. So the present study has been designed to evaluate the heavy metal residues in meat sold in Coimbatore district of Tamil Nadu.

MATERIALS AND METHODS

The study was undertaken to estimate the heavy metal residues viz., cadmium, chromium, copper, lead, nickel and zinc in tissues of goat collected from industrial (Ukkadam) and non-industrial (Vadavalli) areas of Coimbatore, earmarked as industrially polluted district by (Tamil Nadu Pollution Control Board (TNPCB). Sums of two hundred and forty fresh samples of goat, each weighing approximately 250 g were randomly collected according to standard procedure prescribed by the (AOAC, 1990). Wet ashing method was followed for sample digestion. Five grams of samples were taken in 100 ml conical flask along with glass beads and 25 ml of triple glass distilled water added. About 10 ml each of concentrated nitric acid and 60% perchloric acid was added to the contents of the conical flask. The conical flask was heated for about 30 minutes at a temperature of 135˚C. Subsequently the temperature was reduced to 70˚C and maintained, with intermittent shaking till the solution become clear. The solution was quantitatively transferred into a 50 ml volumetric flask and volume made upto the mark with triple glass distilled water. Samples were analyzed by using inductively coupled plasma optical emission spectroscopy (ICP-OES) (The Agilent Technologies 700 Series). The instrumental conditions used for the measurement of heavy metals were as follows: RF Power, 1200W; Plasma flow, 15L/Min; Auxiliary flow, 1.5L/Min; Nebulizer flow, 0.75L/Min; Replicated read time, 3S; Instrument stabilization time, 10S; Sample uptake delay, 25S; Rinse time, 30S. The collected data were subjected to statistical analysis by means of Analysis of variance (ANOVA) as per the procedure given by Snedecor and Cochran (1994).

RESULTS AND DISCUSSIONS

The concentrations of heavy metals in analyzed samples are reported in Table 1, 2, 3, and 4. Cadmium was detected at highest level in kidneys (0.06±0.01ppm) collected from industrial area during rainy season whereas lowest level in muscle (0.01±0.00ppm) collected from non-industrial area during summer. In India, Food Safety and Standards Rules, 2011 has prescribed a standard of (1.5ppm) for cadmium in food. However, none of the samples in this study had cadmium content exceeding the permissible limit. This might be due to raising of animals in uncontaminated areas and inaccessibility of animals to sewage sludge contaminated lands or fertilized land with super phosphate and also animals are not accessed to cadmium contaminated areas viz., mines, smelting plants and metallurgical, galvanotechnical and dye works (Goyer, 1991). Similar results were reported by Abou-Arab (2001) in sheep and goat tissues collected from Egyptian industrial area were 0.02, 0.04 in muscle, 0.26, 0.26 in liver and 0.82, 0.91 in kidneys (mg/g wet weight) respectively. Similarly, Swaileh *et al.*, (2009) reported that the concentration of cadmium in muscle, liver and kidney of goat collected from locally reared animals in West Bank, Palestinian Authority were 0.36, 0.54 and 0.46µg/g on dry basis. Vasanthi (2010) reported that the goats slaughtered at Madras Veterinary College showed high cadmium content in kidneys (0.42ppm) and in muscle (0.42ppm) followed by liver (0.35ppm).

Highest concentration of chromium was recorded in liver (2.61±0.59ppm) collected from industrial area during summer whereas lowest concentration in muscle (0.02±0.00ppm) collected from non-industrial area, during rainy season.

In India, there is no specific standard limit for chromium content in fresh meat. Harrison and Staples (1955) who has stated that the tissue levels of 30ppm in the liver and 4µg/ml in the whole blood is confirmed of chromate poisoning. The low level of chromium recorded in the tissues of goat might be due to non accessibility of animals to graze in the potential anthropogenic source of chromium viz., electroplating factories, leather tanneries, wood preserving, metal processing, chromium plating, alloy preparation, petroleum refining and manufacturing of automobile parts and textile manufacturing facilities. Similar results were reported by Akan *et al.,* (2010) in liver and kidneys of sheep and goat obtained from Kasuwan Shanu market in Maiduguri metropolis, Bornol state, Nigeria had chromium (µg/g) content of 0.76, 1.22 in liver; 0.65, 0.85 in kidneys, respectively. Highest concentration of copper was recorded in kidneys (27.88±1.23ppm) collected from industrial area during rainy season whereas lowest concentration in muscle (0.82±0.04ppm) collected from non-industrial area during summer. In India, FSSA, (2011) prescribed a specific standard for copper in food upto 30ppm. The results obtained in this study were below the permissible limit, this might be due to non-exposure of animals to the environmentally contaminated areas, excessive amounts of copper supplementation or feeds that have not been contaminated with copper compounds used for agricultural or industrial purposed (Underwood, 1977). Sabir *et al.,* (2003) reported that copper in mutton and chevon purchased from local market as well as different spots of Nalahs in Ravine were 70ppm and 69ppm, respectively. Swaileh *et al.,* (2009) reported that the concentration of copper in muscle, liver and kidneys of sheep and goat collected from locally reared animals in West Bank, Palestinian Authority were 2.78, 3.97; 136.65, 183.61; 6.46, 5.90 (µg/g on dry basis), respectively.

Highest concentration of lead was recorded in liver (0.15±0.07ppm) collected from industrial area during summer whereas lowest concentration in muscle (0.01±0.00ppm) collected from non-industrial area during rainy season. In India, FSSA, (2011) has fixed a specific standard for lead (2.5ppm) in the food. The level of lead recorded in this study was much lower than the permissible limit, this might be due, the recent years, there has been a remarkable decline in lead levels in animal tissues throughout the developed countries; attributable to the phasing-out of leaded petrol. Moreover, these animals might not be exposed to the source of lead dioxide particulates or vapours of alkyl lead that had been evaporated from automobile fuel system would have deposited in the plants grown on the road sides or the adjoining area and there were chances for animals to consume these plants during grazing to get accumulated in the tissues, Goyer (1991). Similar results were reported by Stavreva-veselinovska and Zivanovic (2010) reported that the lead concentration (mg/kg wet weight) in goat organs viz., muscle, liver and kidneys collected from three localities of Probistip were 0.058, 0.305 and 0.412 in industrial zone; 0.094, 0.625 and 0.740 in village stromas; 0.005, 0.078, 0.165 in control point respectively. Vasanthi (2010) reported the toxic metal (lead) content in muscle and organs of goat slaughtered at Madras Veterinary College had lead below detectable level (BDL) whereas in market samples, the highest lead content was found in liver at 29.84ppm. Highest concentration of nickel was noticed in liver (3.69±1.58ppm) collected from non-industrial area whereas lowest concentration in kidneys (0.07±0.01ppm) collected from non-industrial area during rainy season. In India, there is no specific standard available for nickel in fresh and processed meat. The permissible limit of nickel in food was below 0.5mg/kg, according to WHO and USSR standard. Similar results were reported by Sabir *et al.,* (2003) found the concentration of nickel in meat samples (mutton and chevon) purchased from local market as well as different spots of Nalahs in Ravine were 1 to 2ppm respectively. Akan *et al.,* (2010) reported that the concentration of nickel (µg/g) in the tissues of sheep and goat obtained from Kasuwan Shanu Market in Maiduguri Metropolis, Borno State, Nigeria were 0.09, 0.04 in liver while 0.19, 0.13 in kidneys, respectively.

Highest concentration of zinc was recorded in muscle (12.70±2.54ppm) collected from industrial area during summer whereas lowest concentration in liver (1.99±0.26ppm) collected from non-industrial area during rainy season. Zinc concentration recorded in the tissues of goat was below the permissible level prescribed by FSSA, (2011). The lower level of zinc might be due to animals are not raised close to zinc refineries as well as zinc supplemented cattle indicating that in ruminants this element is closely regulated by precise and specific homeostatic mechanisms. Similar result was reported by Fonglan (1998) who found the concentration of zinc (mg/kg) in kidneys of sheep collected from industrial and non-industrial areas of Tamil Nadu were 64.75 and 64.42, respectively. Abraham *et al.*, (1998) reported that the zinc content (ppm) in buffalo tissues collected from MVC as well as market; he had observed the highest zinc content in muscle of 22.29 and 33.20ppm for both the region but the level reported in these two regions were below the permissible level of 50ppm prescribed by MFPO (1973) for meat food product.

CONCLUSIONS

It is concluded that the study reveals there is no toxic elements like cadmium, chromium, copper, lead, nickel and zinc in chevon (goat meat) above the permissible level prescribed by FSSA (2011). This study will also help to fix standards for metals like chromium and nickel for which no standards are available in FSSA, (2011).

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APPENDICES

Table 1: Range of Heavy Metal Contents (Ppm) in Muscle, Liver and Kidneys of Goat Collected from Coimbatore District

Elements (ppm)	Area(s)	Muscle	Liver	Kidneys
Cadmium	Industrial	0.02-0.09	0.04-0.13	0.03-0.20
	Non-industrial	0.01-0.05	0.01-0.06	0.02-0.10
Chromium	Industrial	0.02-1.80	0.03-2.72	0.07-0.84
	Non-industrial	0.01-1.23	0.02-0.19	0.05-0.09
Copper	Industrial	1.20-5.81	3.21-29.72	3.50-8.00
	Non-industrial	0.65-2.00	3.54-28.52	1.76-6.24
Lead	Industrial	0.01-0.18	0.03-0.20	0.03-0.07
	Non-industrial	0.01-0.03	0.01-0.07	0.01-0.05
Nickel	Industrial	0.05-0.30	0.09-0.91	0.03-0.63
	Non-industrial	0.15-1.85	1.00-4.52	0.05-1.00
Zinc	Industrial	2.00-14.00	5.00-8.43	3.21-10.00
	Non-industrial	1.74-12.00	1.52-5.23	2.00-4.00

Table 2: Mean ± S.E. of Heavy Metal Contents (Ppm) in Muscle, Liver and Kidneys of Goat Collected from Coimbatore District during Summer Season

Elements (ppm)	Area(s)	Muscle	Liver	Kidneys	"F"
Cadmium	Industrial	0.03±0.00^{B}	0.05±0.00	0.06±0.00	2.01
	Non-industrial	0.01±0.00^{A}	0.02±0.00	0.03±0.00	0.08
	"t"	2.10*	1.81	0.61	
Chromium	Industrial	1.78±0.53^{bB}	2.61±0.59^{cB}	0.63±0.27^{a}	11.09*
	Non-industrial	1.11±0.03^{A}	0.15±0.06^{A}	0.09±0.01	3.14
	"t"	5.05**	4.16**	1.89	
Copper	Industrial	4.83±1.20^{B}	5.14±1.85^{b}	6.49±1.72^{B}	0.99
	Non-industrial	0.82±0.04^{aA}	4.85±1.09^{c}	2.28±0.57^{bA}	30.43**
	"t"	3.74**	0.23	2.51*	
Lead	Industrial	0.11±0.06	0.15±0.07	0.05±0.00	0.98
	Non-industrial	0.02±0.00^{a}	0.05±0.00^{b}	0.03±0.00^{a}	7.22**
	"t"	1.66	2.01	1.10	
Nickel	Industrial	0.28±0.01^{a}	0.81±0.31^{b}	0.44±0.06^{a}	5.14*
	Non-industrial	1.12±0.51	1.13±0.33	0.83±0.42	0.16
	"t"	1.02	0.65	0.93	
Zinc	Industrial	12.70±2.54^{B}	7.65±1.69	4.27±0.54^{B}	3.05
	Non-industrial	10.44±1.93^{cA}	4.89±0.71^{b}	3.14±0.42^{aA}	11.69**
	"t"	3.64**	1.56	3.29**	

Means bearing different superscripts in a row (^{abc}) and in a column (^{AB}) differ significantly **-significance at ($p<0.01$); *-significance at ($p<0.05$)

Table 3: Mean ± S.E. of Heavy Metal Contents (Ppm) in Muscle, Liver and Kidneys of Goat Collected from Coimbatore District during Rainy Season

Elements (ppm)	Area(s)	Muscle	Liver	Kidneys	"F"
Cadmium	Industrial	0.07±0.02^{B}	0.10±0.04^{B}	0.16±0.01	0.99
	Non-industrial	0.03±0.00^{A}	0.05±0.00^{A}	0.09±0.02	1.42
	"t"	2.11*	2.22*	0.85	
Chromium	Industrial	0.03±0.00	0.04±0.00	0.08±0.00	0.89
	Non-industrial	0.02±0.00	0.05±0.00	0.06±0.00	1.06
	"t"	1.08	0.42	1.44	
Copper	Industrial	1.48±0.82^{B}	27.88±1.23	4.56±1.21	0.89
	Non-industrial	1.01±0.07^{aA}	27.13±1.61^{c}	4.47±1.76^{b}	5.96**
	"t"	2.16*	0.04	1.02	
Lead	Industrial	0.02±0.00	0.04±0.00	0.06±0.00	0.05
	Non-industrial	0.01±0.00	0.02±0.00	0.02±0.00	3.84
	"t"	0.78	1.41	0.36	
Nickel	Industrial	0.08±0.02^{A}	0.18±0.04^{A}	0.07±0.01	2.23
	Non-industrial	0.26±0.04^{bB}	3.69±1.58^{cB}	0.09±0.05^{a}	4.96*
	"t"	3.83**	2.21*	4.49	
Zinc	Industrial	2.53±0.25^{a}	6.64±1.62^{bB}	9.06±1.63^{cB}	6.09*
	Non-industrial	2.49±0.53	1.99±0.26^{A}	2.18±0.31^{A}	0.44
	"t"	0.05	2.82**	4.16**	

Means bearing different superscripts in a row (^{abc}) and in a column (^{AB}) differ significantly **-significance at ($p<0.01$); *-significance at ($p<0.05$)

Table 4: Comparison (Mean ± S.E.) of Heavy Metal Contents (Ppm) in the Tissues of Goat Collected from Industrial and Non-Industrial Areas of Coimbatore District during Summer and Rainy Season

Elements (ppm)	Tissues	Industrial Area		"t"	Non-industrial Area		"t"
		Summer	Rainy		Summer	Rainy	
Cadmium	Muscle	0.03±0.00	0.07±0.01	1.89	$0.01±0.00^{A}$	$0.03±0.00^{B}$	3.82
	Liver	$0.05±0.00^{a}$	$0.10±0.04^{b}$	2.50	0.02±0.00	0.05±0.00	1.44
	Kidneys	$0.06±0.00^{a}$	$0.16±0.05^{b}$	2.19	$0.03±0.00^{a}$	$0.09±0.02^{b}$	0.38
Chromium	Muscle	$1.78±0.53^{B}$	$0.02±0.00^{A}$	5.23	$0.11±0.03^{b}$	$0.02±0.00^{a}$	2.82
	Liver	$2.62±0.59^{B}$	$0.04±0.00^{A}$	4.42	$0.15±0.06^{b}$	$0.05±0.00^{a}$	2.21
	Kidneys	0.63±0.27	0.08±0.00	1.39	0.09±0.01	0.06±0.00	2.28
Copper	Muscle	$4.83±1.28^{b}$	$1.49±0.18^{a}$	3.35	$0.82±0.04^{A}$	$1.01±0.02^{B}$	3.73
	Liver	5.15±0.58	27.88±2.32	0.16	4.85±1.09	4.47±1.76	0.35
	Kidneys	6.49±1.72	4.56±1.31	0.71	2.28±0.57	27.13±1.60	0.87
Lead	Muscle	0.11±0.06	0.12±0.00	1.58	0.02±0.00	0.01±0.00	2.57
	Liver	0.15±0.07	0.04±0.00	1.96	0.05±0.00	0.02±0.00	0.36
	Kidneys	0.05±0.00	0.06±0.00	1.14	0.03±0.00	0.02±0.00	0.02
Nickel	Muscle	$0.28±0.05^{B}$	$0.08±0.02^{A}$	3.96	1.12 ±0.51	0.26±0.00	1.72
	Liver	$0.81±0.\ 31^{b}$	$0.18±0.04^{a}$	2.83	1.13±0.33	3.70±1.59	1.77
	Kidneys	$0.44±0.06^{B}$	$0.09±0.04^{A}$	4.14	$0.83±0.42^{b}$	$0.07±0.02^{a}$	1.82
Zinc	Muscle	$12.73±2.55^{B}$	$2.50±0.52^{A}$	3.48	$10.44±1.93^{B}$	$2.53±0.26^{A}$	3.97
	Liver	$7.65±0.71^{B}$	$2.00±0.26^{A}$	3.36	4.89±0.71	1.99±0.26	0.99
	Kidneys	$4.27±0.54^{A}$	$9.06±1.63^{B}$	3.31	$3.14±0.42^{B}$	$2.18±0.31^{A}$	4.18

Means bearing different superscripts in a row differ significantly ^{AB}-significance at ($p<0.01$); ^{ab} -significance at ($p<0.05$)